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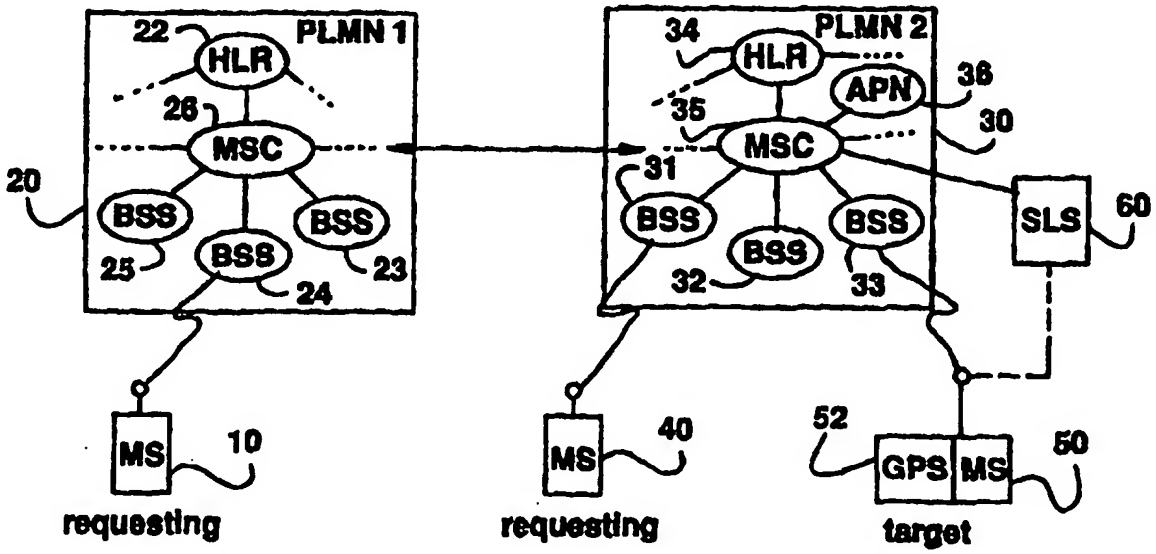

(57) Abstract

Position information regarding a mobile station is determined and provided upon request. In one situation, mobile station position is determined in response to a request from another mobile subscriber (10, 40) and displayed (226) on the requesting mobile station display. Mobile station position is also determined in response to a request from a land line user (70) and provided through either a synthesized voice communication (233), a data message (225) or a facsimile message (237). Mobile station positions are further provided in response to law enforcement (320) and other public service entity (422) requests. This information is useful in tracking a mobile station (312, 412) either during a call or when the mobile station is idle. In another instance mobile station location information is used to insure routing (434) of emergency (911) calls (424) to the proper public safety answering point (422). The system further has the capability of being programmed with certain response criteria applicable to the determination of mobile station position. Such criteria include accuracies, confidence factors, periods between location reports, and location determination technique.

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METHOD AND APPARATUS FOR COMMUNICATING INFORMATION ON MOBILE STATION POSITION WITHIN A CELLULAR TELEPHONE NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to locating the geographic position of a mobile station operating within a cellular telephone network and, in particular, to the provision of the determined geographic position information in response to requests from, for example, other subscribers and public service agencies, and further to the use of mobile station location information to direct the routing of emergency cellular telephone calls and the rendering of emergency assistance.

Description of Related Art

Cellular telephone networks typically include a plurality of base stations connected to a centrally-located switch commonly referred to as a mobile switching center. Base stations may be spaced apart from each other by distances of between one-half and twenty kilometers. Each base station is assigned a number of two-way voice channels and control channels. The voice channels are used to transmit voice signals to and from proximately located mobile stations. The control channels are used for the transmission of control information to and from those mobile stations, usually for the purpose of establishing a voice communications link.

The control channels used for transmissions from a base station to a mobile station are called the "forward" control channels. The forward control channel is generally a common channel, which means that any mobile station may access the channel and listen for messages transmitted by the base station. Conversely, the control channels used for transmissions from the mobile station to the base station are referred to as "reverse" control channels. The reverse control channels may be common, in

which case there may be contention for access, or may be dedicated, which means that they are reserved or assigned for the use of a single mobile station in making a transmission to a base station.

Cellular telephone networks typically include a plurality of interconnected mobile switching centers, including a gateway mobile switching center through which the network interconnects with the conventional public switched telephone network. At least one home location register is included within a cellular telephone network. The home location register is used to store subscriber information including an identification of current mobile station location within the network.

In response to an incoming call dialed to a given mobile station, a signal is sent to the home location register requesting routing information through the network to the called mobile station. The home location register looks up the current location of the mobile station and contacts the currently serving mobile switching center to pre-route the call and retrieve a temporarily location directory number which is used to route the call through the network for delivery to the mobile station. The serving mobile switching center retrieves from a visitor location register an identification of the cell within which the called mobile station is currently located. The mobile switching center then instructs the base station associated with that cell to page the mobile station. Responding to the page, the mobile station requests assignment of a channel, and the network routes the call through the serving mobile switching center and over the assigned channel.

Conventional cellular telephone technology, by itself, does not include the capability of pinpointing, with any reasonable or useful degree of accuracy, the location of the mobile subscriber. For example, using a conventional cellular telephone network, the extent of the location precision typically available is to identify

the cell within which a mobile station is located. Some cells, though, have a coverage radius in excess of one kilometer. Thus, cell location identification accordingly provides little, if any, assistance in actually locating the position of the subscriber. Accordingly, a number of systems have been proposed to assist in the location determination and provide more accurate position information. One system utilizes a triangulation or arcuation process to determine an approximate location of the caller through an analysis of signal strength measurements and/or propagation delay times of the cellular communications. Another system utilizes the existing Global Positioning System (GPS) with a GPS receiver attached to the cellular telephone to obtain geo-coordinates for the mobile station.

Although many systems have been proposed for more precisely identifying the location of a mobile station, it is equally important that the determined position information be provided to the persons or entities who need the information. Take first, for example, the cellular subscriber himself. It is not unusual for the subscriber to get lost and realize that they need to know their precise location in order to obtain directions. Absent the presence of landmarks or other location indicia (like street signs), the subscriber has no way of identifying their location without asking for help. In certain situations, like in rural areas, such help may not be available. It would be an advantage then if the cellular subscriber could use his or her mobile station to signal the cellular telephone network to make a position determination and relay that information to the subscriber for subsequent use in calling for directions.

In another example, consider the person who desires to know the location of a cellular subscribing family member or friend. The family member or friend may be late for an appointment and the person becomes concerned that they may be lost, injured or otherwise in need of

assistance. Alternatively, the person may suspect that the family member is engaging in an undesirable activity and wish to monitor their location. In any case, it would be an advantage if that person could signal the cellular telephone network to make a position determination on a particular mobile station and relay that information back to the person for evaluation.

In yet another example, consider the situation where a law enforcement agency desires to know the location of either a mobile station or the person using the mobile station. Thus, for a mobile station located in a stolen vehicle, the law enforcement agency would want to monitor the location of the mobile station, and hence the stolen vehicle itself, to assist in apprehending the thief. Alternatively, a law enforcement agency may have an interest in monitoring not only the cellular telephone communications made by a cellular service subscripting suspect, but also the locations from which those calls are occurring. It would be an advantage, then, if the law enforcement agency could signal the cellular telephone network to make a position determination on a particular mobile station and relay that information back for use in tracking the suspect.

Cellular subscribers now frequently use their mobile stations to make emergency (911) calls. Unlike conventional land line telephones, mobile stations have no fixed address relating to a location which may be obtained by the public safety answering point (PSAP) when an emergency call is made. Accordingly, it would be an advantage, then, if the public safety answering point could signal the cellular telephone network to make a position determination on a particular mobile station from which an emergency call originates and relay that information back for use in dispatching emergency service aid.

Furthermore, knowing the location of the mobile station does not comprise the only concern in rendering

emergency services in response to a cellular emergency call. It is also important that the emergency cellular call be routed through the network to the proper public safety answering point in those instances where the calling mobile station is roaming. In such cases, it would be an advantage if a switch handling the call could request location information on a particular roaming mobile station from which an emergency call is originated and use that information in determining which public safety answering point is the correct public safety answering point (based on proximity to the mobile station) to handle the call and dispatch the emergency service aid. It would further be an advantage if position information could be determined in response to that same request and provided to the correct public safety answering point for use in directing emergency services personnel to the aid of the subscriber.

SUMMARY OF THE INVENTION

The present invention comprises a system for selectively conveying mobile station position information to requesting entities. In a first embodiment, the system responds to a position request from another mobile station by routing the request to the serving switching node, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting mobile station. In another embodiment, the system responds to a position request from a land line telephone user by routing the request to the serving switching node, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting user for presentation in either a synthesized oral manner, as a data message, or as a facsimile message. In another embodiment, the requesting entity comprises a public service entity such as a law enforcement agency, and the system responds to a position

request by routing the request to the serving base station controller, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting entity.

The present invention still further comprises a system for determining mobile station location, and processing location information to identify a proper public safety answering point to which an emergency call from that mobile station should be routed. In connection therewith, an anchor exchange recognizes that the mobile station is roaming and wants to place an emergency call, and requests from the serving exchange an identification of the mobile station location. This information is then used to route the call to the proper public safety answering point. Furthermore, either the anchor exchange or the public safety answering point to which the emergency call is routed may then make a request for the determination of mobile station position, with the returned information useful in directing the dispatch of emergency services aid.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is a block diagram of a cellular telephone network in accordance with the present invention which supports responding to requests regarding mobile station position;

FIGURE 2 is a block diagram of a base station system like that used in the cellular telephone network of FIGURE 1;

FIGURE 3 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a

first scenario for providing position information on a target mobile station;

FIGURE 4 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a second scenario for providing position information on a target mobile station;

FIGURE 5 is a block diagram of a telephone network in accordance with the present invention which supports responding to requests regarding mobile station position;

FIGURE 6 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 for providing position information on a target mobile station;

FIGURE 7 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a data terminal;

FIGURE 8 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a telephone;

FIGURE 9 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a facsimile machine;

FIGURE 10 is a block diagram of a cellular telephone network in accordance with the present invention which supports delivery of mobile station position information to public service entities;

FIGURE 11 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 10 in providing position information on a mobile station during an ongoing cellular voice/data communication;

FIGURE 12 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 10 in providing information on a mobile station while in an idle operating mode;

FIGURE 13 is a block diagram of a cellular telephone network in accordance with the present invention equipped to provide emergency situation caller assistance; and

FIGURE 14 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 13 in providing location information on a mobile station for purposes of properly routing an emergency cellular call.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 1 wherein there is shown a block diagram of a cellular telephone network including a plurality of individual Public Land Mobile Networks (PLMNs) 20 and 30. The first Public Land Mobile Network 20 includes a mobile switching center 26 connected to a plurality of base station systems (BSSs) 23, 24 and 25. It will, of course, be understood that the Network 20 likely includes a plurality of mobile switching centers 26. The mobile switching center 26 is further connected to a home location register 22. The second Public Land Mobile Network 30 is similarly configured having a mobile switching center 35 connected to a plurality of base station systems 31, 32 and 33. Again, it is likely that the Network 30 includes a plurality of mobile switching centers 35. The mobile switching center 35 is further connected to a home location register 34. At least one mobile switching center 26 of the first Public Land Mobile Network 20 and at least one mobile switching center 35 of second Public Land Mobile Network 30 are interconnected for both voice/data communications and signaling transmissions in a manner well known to those skilled in the art.

Reference is now additionally made to FIGURE 2 wherein there is shown a block diagram of the base station systems 23, 24, 25, 31, 32 or 33. Each base station system comprises a base station controller (BSC) 108 connected to a plurality of base stations (BS) 102, 104

and 106. At least one base station is provided for each cell in the network. It is through the base stations 102, 104 and 106 that radio frequency communications with proximately located mobile stations (MS) are effectuated. The base station controller 108 is connected to the mobile switching center 26 or 35 shown in FIGURE 1. Operation of a Public Land Mobile Network 20 or 30 in providing cellular communications services to mobile stations through the base station controller 108 and base stations 102, 104 and 106 is well known to those skilled in the art.

Referring now again to FIGURE 1, instances often arise wherein a subscriber (not shown) having a mobile station 10 or 40 desires to know the geographic position/location of another (target) subscriber mobile station 50. The cellular telephone network of FIGURE 1 supports responding to mobile station 10 and 40 position requests by determining the position of the target mobile station 50 and responding to the requesting mobile station in an appropriate manner.

Take first the scenario where the requesting mobile station 10 is located in a different Public Land Mobile Network 20 than the target mobile station 50. Additional reference is now made to FIGURE 3 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a first scenario for providing position information on the target mobile station 50. Requesting mobile station 10 first (action 200) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. A signal 202 is then sent over a control channel by the requesting mobile station 10 to its serving base station system 24 using an Unstructured Supplementary Service Data (USSD) or Direct Transfer Access Point (DTAP) message. Responsive thereto, the base station system 24 routes (signal 204) the request to the

mobile switching center 26. The mobile switching center 26 analyzes the directory number of the requesting mobile station 10 to determine its home location register 22. A query (signal 206) is then sent to the home location register 22 requesting confirmation that the requesting mobile station 10 is subscripted to the requested mobile station position service feature. A response (signal 208) is sent back to the mobile switching center 26. Alternatively, the requesting mobile station 10 subscription may be checked by the mobile switching center 26 itself (through its visitor location register), thus obviating the need for signals 206 and 208. If the response is affirmative, the mobile switching center 26 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message, referred to as a provide location information (PLI) request signal 210, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 212) to mobile switching center 35. A location determination (action 214) with respect to the target mobile station 50 is then made in accordance with one of a number of known procedures. These procedures are briefly described later. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 again using a modified Mobile Application Part message signal 216. The information is then forwarded by signals 218, 220 and 222 through the mobile switching center 26 and base station system 24 to the requesting mobile station 10. The information is then processed (action 224) by the mobile station 10 and displayed (action 226) for subscriber review.

In a second scenario, the requesting mobile station 40 is located in the same Public Land Mobile Network 30

as the target mobile station 50. Additional reference is now made to FIGURE 4 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a second scenario for providing position information on a target mobile station 50. Requesting mobile station 40 first (action 200) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. A signal 202 is then sent over a control channel by the requesting mobile station 40 to its serving base station system 31 using an Unstructured Supplementary Service Data (USSD) or Direct Transfer Access Point (DTAP) signal. Responsive thereto, the base station system 31 routes (signal 204) the request to the mobile switching center 35. The mobile switching center 35 analyzes the directory number of the requesting mobile station 40 to determine its home location register 34. A query (signal 206) is then sent to the home location register 34 requesting confirmation that the requesting mobile station 40 is subscripted to the requested mobile station position service feature. A response (signal 208) is sent back to the mobile switching center 35. Again, subscription verification may be performed directly by the mobile switching center 35 obviating the need for signals 206 and 208. If the response is affirmative, the mobile switching center 35 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message, referred to as a provide location information (PLI) request signal 210, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 212) back to mobile switching center 35. A location determination (action 214) with respect to the target mobile station 50 is then made in accordance with

one of a number of known procedures. These procedures are briefly described herein. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 using a modified Mobile Application Part message signal 216. The information is then forwarded by signals 218, 220 and 222 back through the mobile switching center 35 and base station system 31 to the requesting mobile station 40. The information is then processed (action 224) by the mobile station 40 and displayed (action 226) for subscriber review.

Although mobile stations 40 and 50 are illustrated in FIGURE 1 as being served by the same mobile switching center 35 of the second Public Land Mobile Network 30, it will be understood that this need not necessarily be so. When different mobile switching centers 35 are involved, the signals 212 and 220 are routed to the correct one of the mobile switching centers in a manner well known in the art (and similarly to that illustrated in FIGURE 3).

Reference is now made to FIGURE 5 wherein there is shown a block diagram of a telephone network including a Public Switched Telephone Network 90 and a Public Land Mobile Network 30. The Public Land Mobile Network 30 is similar to that shown in FIGURES 1 and 2 to include a mobile switching center 35 connected to a plurality of base station systems 31, 32 and 33. The mobile switching center 35 is further connected to a home location register 34. The Public Switched Telephone Network 90 is not illustrated in detail, but does include, for purposes of the present invention, an end office exchange (EO) 82. Connected to the end office 82 are a telephone unit (TU) 70, data terminal equipment (DTE) 72 (comprising, perhaps, a personal computer), and a facsimile machine (FAX) 74. The mobile switching center 35 of the Public Land Mobile Network 30 and the end office 82 of the Public Switched Telephone Network 90 are interconnected for both

voice/data communications and signaling transmissions in a manner well known to those skilled in the art.

Instances often arise wherein a person (not shown) having a telephone unit 70 desires to know the geographic position/location of a subscriber mobile station 50. The telephone network of FIGURE 5 supports responding to telephone unit 70 position requests by determining the position of the target mobile station 50 and responding to the requesting person in an appropriate manner.

Reference is now additionally made to FIGURE 6 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 for determining the position of a target mobile station 50. Requesting telephone unit 70 first (action 201) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. The manner of position information delivery (i.e., voice back to the telephone unit, or data to either the data terminal equipment 72 or facsimile machine 74) is also specified. A signal 203 is accordingly sent from the requesting telephone unit 70 to its serving end office 82. Responsive thereto, the Public Switched Telephone Network 90 then confirms (action 205) that the requesting telephone unit 70 is subscripted to the requested mobile station position service feature. If this is confirmed, the end office 82 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message or perhaps a Transaction Control Application Part (TCAP) message, referred to as a provide location information (PLI) request signal 207, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 209) to mobile switching center 35. A location

determination (action 211) with respect to the target mobile station 50 is then made in accordance with one of a number of known procedures. These procedures are briefly described later. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 using a modified Mobile Application Part message signal 213. The information is then forwarded by signals 215 and 217 through the end office 82 of the Public Switched Telephone Network 90 to an adjunct processing node (APN) 76. It will, of course, be understood that the adjunct processing node 76 functionality may be provided within the end office 82 itself. The manner of position information delivery input by the person at the telephone unit 70 is then processed (action 219) to determine whether the position information should be delivered to the telephone unit, data terminal equipment 72 or the facsimile machine 74.

Reference is now made to FIGURE 7 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to the data terminal equipment 72. Following processing in action 219 to identify the data terminal equipment 72 as the delivery destination for the position information, the adjunct processing node 76 properly formats (action 221) the position information for data delivery, initiates a call (action 223) through the end office 82 to the data terminal equipment 72, and transmits the formatted position information over call connection 225.

Reference is now made to FIGURE 8 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to the telephone unit 70. Following processing in action 219 to identify the telephone unit 70 as the delivery destination for the position information, the adjunct processing node

76 initiates a call (action 229) through the end office 82 to the telephone unit 70. Once a call connection 231 is established between the adjunct processing node 76 and telephone unit 70, the adjunct processing node synthesizes (action 233) a voice message relating the determined position information to the requesting person.

Reference is now made to FIGURE 9 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a facsimile machine 74. Following processing in action 219 to identify the facsimile machine 74 as the delivery destination for the position information, the adjunct processing node 76 properly formats (action 221) the position information for facsimile delivery, initiates a call (action 235) through the end office 82 to the facsimile machine 74, and transmits the formatted position information over the established call connection 237.

With reference now again to FIGURES 1 and 5, a plurality of different mechanisms exist for determining the position of the mobile station 50 operating within the cellular telephone network. Although several location determination techniques are discussed below, it will be recognized that any suitable position determination mechanism may be used.

One way to determine position is to rely on information supplied from a Global Positioning System (GPS) transceiver 52 connected to the target mobile station 50. Responsive, perhaps, to requests from a base station system, or on a periodic basis, geo-coordinates are extracted by the target mobile station 50 and transmitted over a control channel of the air interface to the base station system. This information is then relayed to the serving mobile switching center, processed by an adjunct processing node (APN) 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back

through the network for presentation to the requesting entity.

A second way to determine position is to use the cell area where the target mobile station 50 is currently located. Identification information for the currently serving base station and cell is available to the network and in particular to the base station system. This information is relayed to the serving mobile switching center, processed by the adjunct processing node 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity.

A third way to determine position is to use measurements (signal strength or timing advance) made by the base stations in the vicinity of the target mobile station 50. Responsive, perhaps, to requests from a base station system, or on a periodic basis, measurement information is acquired by the base station system serving the target mobile station 50 and relayed to the mobile switching center. This information is then processed by the adjunct processing node 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity. In particular, the adjunct processing node 36 utilizes well known triangulation and arcuation processes to identify a position from the received measurement information.

A fourth way to determine position is to use measurements (signal strength or timing advance) made by the target mobile station 50 itself. Responsive, perhaps, to requests from a base station system, or on a periodic basis, measurement information is acquired by the target mobile station 50 and relayed to the mobile switching center through the serving base station system. This information is then processed by the adjunct processing node 36 in the manner described above in connection with

the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity. In particular, the adjunct processing node 36 utilizes well known triangulation and arcuation processes to identify a position from the received measurement information.

A fifth way to determine position is to rely on a determination made by a separate location system (SLS) 60. The separate location system 60 utilizes a known location determination system, such as GPS, satellite Doppler, LORAN-C, direction finding, time or arrival triangulation (arcuation), or signal strength triangulation (arcuation). Responsive to a request, or perhaps on a periodic basis, the separate location system 60 sends position information to the mobile switching center. This information is then processed in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity.

Reference is now made to FIGURE 10 wherein there is shown a block diagram of a cellular telephone network 300 comprising a mobile switching center (MSC) 302, a base station controller (BSC) 304, and a plurality of base stations (BS) 306. The base station controller 304 and associated base stations 306 form a base station system (BSS) 308. Each base station 306 is configured to engage in radio frequency communications over an air interface 310 with proximately located mobile stations (MS) 312. The air interface 310 supports the transmission of both voice/data communications as well as signaling communications. In general, communications are effectuated with those mobile stations 312 located near or within the confines of a cell 314 associated with each base station 306. The mobile switching center 302 and base station controller 304 are connected via a communications link 316 which supports the transmission of both voice/data communications as well as signaling

communications. The base station controller 304 and associated base stations 306 are connected via communications links 318 which, like the links 316, support the transmission of both voice/data communications as well as signaling communications. Operation of the cellular telephone network 300 in providing conventional cellular voice/data calling services to mobile station subscribers is well known to those skilled in the art, and accordingly will not be discussed herein.

A law enforcement agency is often authorized to monitor cellular telephone calls to obtain evidence for use in criminal investigations. To accomplish this goal, a monitoring center (MC) 320 is established which may include a tape recorder 322 for recording the voice conversation that is being monitored. The physical connection with the voice/data communications portion of the cellular telephone network 300 is made through a tap (generally shown at 324). The tap 324 may be made at any location within the cellular telephone network 300 in a manner well known to those skilled in the art, but is typically made at a selected one of the mobile switching centers 302 associated with the base station 306 and cell 314 where the mobile station 312 is currently located (roaming).

A number of instances may arise where the location of a mobile station 312 (or its possessing cellular subscriber) needs to be known by the law enforcement agency. One instance occurs in connection with the monitoring of an ongoing cellular telephone call. Another instance occurs when the mobile station 312 is idle, but the law enforcement agency desires to track its location.

Reference is now additionally made to FIGURE 11 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 300 of FIGURE 10 in providing position on a mobile station 312 during an ongoing cellular voice/data communication 330. It is assumed that all of

the conventional, well known, cellular network operations preceding the establishment of the actual communication 330 (for example, authentication, ciphering, call set-up) have already occurred. The portion of the voice/data communication 330 carried over the air interface 310 utilizes a traffic channel (TCH). A control channel (CCH) is also provided over the air interface 310 for parallel mobile station 312 use during the ongoing call.

Suppose now that the law enforcement agency desires to know the location of the mobile station 312 which is engaging in the communication 330. From either its monitoring center 320 (as shown) or another selected location, the law enforcement agency signals 332 the network 300, and in particular the serving mobile switching center 302, to request location information. This request signal 332 includes not only the identification number (MIN, IMSI, IMEI, MSISDN, and/or MSID) of the mobile station 312 to be located, but also the degree of accuracy to be provided with the location determination. This degree of accuracy parameter specifies the precision with which the location determination is expected to be made (for example, actual location within one-hundred fifty meters radius of determined location).

Once the request signal 332 is received by the serving mobile switching center 302, the identification number of the mobile station 312 to be located is processed (action 334), and it is determined that the mobile station at issue is engaged in the communication 330. Thus, the network does not have to search (for example, page) for the mobile station 312 before making the location determination. A position request signal 336 is then sent by the mobile switching center 302 to the base station system 308 serving the mobile station 312 over the communications link 316 as a connection oriented signaling connection control part (SCCP) session. The position request signal 336 includes a plurality of

parameters in addition to the parameters specified in the location request signal 332, including: the confidence factor with which the location position is to be reported; the expected method of reporting the location position; the periodicity with which reports are to be made; and, the kind of location determination that is to be made. The confidence factor parameter specifies the degree of confidence with which mobile station 312 location must be determined (for example, seventy percent in view of the specified accuracy parameter). The method of reporting parameter specifies that either: spontaneous position information is expected; single position information is expected; periodic position information is expected; or, no position information is expected. The periodicity parameter specifies how often (for example, every three minutes) mobile station 312 position is to be determined and reported to the requesting entity. The kind of location determination parameter specifies which one of a plural number of available determination methods (for example, signal strength analysis, timing advance analysis, or global positioning system determination) is to be used in determining mobile station 312 position.

Responsive to the position request signal 336, the base station system 308 serving the mobile station 312 makes the requested position request determination (action 338). The making of the position request determination in action 338 can take on one of several options. First, for example, if the mobile station 312 is equipped with a global positioning system (GPS) receiver 340, and if the mobile station has transmitted its geo-coordinates to the base station system 308 over the control channel (CCH) of the air interface 310, and further if the kind of location determination parameter specifies GPS, the action 338 merely comprises the capturing of the transmitted information, and the formatting of the position information for transmission back to the mobile switching center 302. Second, on the other hand, if the kind of

location determination parameter specifies one of the measurement location methods (like, signal strength analysis or timing advance analysis) the action 338 primarily involves the capturing of the requisite measurement information. Then, if the base station system 308 is connected to a location processing device (LPD) 340, the action 338 further includes the processing of the measurement information to determine mobile station 312 position, and the formatting of the position information for transmission back to the mobile switching center 302. If no location processing device (LPD) 340 is immediately available to the base station system 308, the action 338 includes the collection of the measurement data, and the formatting of the position information for transmission back to the mobile switching center 302. In connection with the measurement location methods, if the measurement data is collected by the mobile station 312 itself (for example, during mobile assisted hand-off measurement), the data is transmitted to the base station system 308 over the control channel (CCH) of the air interface 310. Alternatively, the measurement data is collected by the base station 306 portion of the base station system 308 (for example, during hand-off determination or timing advance analysis).

Once the position request determination in action 338 is completed, a responsive position indication signal 342 is then sent by the base station system 308 serving the mobile station 312 to the mobile switching center 302 over the communications link 316 as a connection oriented signaling connection control part (SCCP) session. The method of reporting parameter within the position request signal 336 specifies the expected nature with which the position indication signal 342 is to be sent by the base station system 308. If the parameter specifies that spontaneous position information is expected, each time the position of the mobile station 312 is determined in action 338 with a confidence factor equal or superior to

the factor specified in the confidence factor parameter of the position request signal 336, the position indication signal 342 is spontaneously sent. If the parameter specifies that single position information is expected, the action 338 implemented by the base station system 308 tries to achieve the position of the mobile station 312 within the preset confidence factor and respond with the position indication signal 342 within a preset time period. If the time period expires before the confidence factor is met, the base station system 308 then responds with the position indication signal 342 which includes an estimated confidence factor for the determined position. If the parameter specifies that periodic position information is expected, the action 338 implemented by the base station system 308 responds with the position indication signal 342 with or without meeting the preset confidence factor, and thereafter responds according to the periodicity specified by the periodicity parameter. If the parameter specifies that no position information is expected, the action 338 implemented by the base station system 308 responds with the position indication signal 342 which does not include any position information and stops any position information process related to that particular mobile station.

The location processing device 340 need not be directly connected to the base station system 308. Instead, or additionally, the device 340' may be directly connected to the mobile switching center 302. In such a case where the position determination is not made in association with the base station system 308 (i.e., the action 338 involves the collection of and the formatting of the measurement data), the measurement data is transmitted to the mobile switching center 302 in the position indication signal 342 and the requested position request determination (action 338') is thereafter made by the location processing device 340'.

Following receipt of each position indication signal 342 by the mobile switching center 302, the position information is processed and/or formatted (action 344), if necessary, and a request location information response signal 346 is transmitted from the mobile switching center to the monitoring center 320 (as shown) of the requesting law enforcement agency. It will, of course, be understood that the requesting entity need not necessarily be restricted to a law enforcement agency as shown. In fact, the position information provided by the network 300 is equally important to other public service agencies such as the fire department and emergency services department (ambulance and rescue squads). Furthermore, the position information is also valuable in fleet/delivery vehicle environments to track the locations of vehicles and personnel. As yet another alternative, the mobile station 312 itself may comprise the requesting entity.

Reference is now made to FIGURE 12 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 300 of FIGURE 10 in providing position information on a mobile station 312 while in an idle operating mode. Unlike the operation described in connection with FIGURE 11, when the request signal 332 is received, the serving mobile switching center 302 may not know where the mobile station 312 with the specified identification number operating in idle mode is located. Thus, the network 300 must search (for example, page) for the mobile station 312. Instead of sending the position request signal 336, the mobile switching center 302 sends a position/tracking request signal 350 to perhaps plural ones of the base station systems 308 (only one shown) over the communications link 316 as a connection-less signaling connection control part (SCCP) session. The position/tracking request signal 350 is sent to plural base station systems 308, rather than a single base station system as with the position request signal 336,

in those instances where the location within the network 300 of the idle mobile station 312 is not known. This position/tracking request signal 350 includes the same parameters as the previously described position request signal 336 including Mobile Station Identification (MIN, IMSI, IMEI, MSISDN, and/or MSID).

Responsive to the position/tracking request signal 350, the base station system 308 builds a tracking group (action 352), analogous to a paging group, and broadcasts a tracking request signal 354, analogous to a paging request signal, through each of its associated base stations 308 (not shown), in an attempt to reach the idle mobile station 312. The tracking request signal 354 is transmitted by the base stations 306 using a common control channel (CCCH) over the air interface 310. If the idle mobile station 312 receives the tracking request signal 354, it transmits a channel request signal 356 to the base station system 308 using a dedicated control channel (DCCH) of the air interface 310. The base station system 308 responds with the assignment of a channel (signal 358), and the mobile station 312 replies by sending a tracking response signal 360, which is analogous to a paging response. This tracking response signal 360 may additionally include geo-coordinate and/or measurement information relating to mobile station 312 position determination.

The base station system 308 then forwards the tracking response signal 360 to the mobile switching center 302 over the communications link 316 as the responsive position indication signal 342, again analogous to the paging response, using a connection oriented signaling connection control part (SCCP) session. If the base station system 308 is connected to the location processing device (LPD) 340, the position request determination (action 338) is performed, and any received measurement information is processed to determine mobile station 312 position. The determined position information

is then transmitted to the mobile switching center 302 using the responsive position indication signal 342. If no location processing device 340 is immediately available to the base station system 308, or if global positioning system geo-coordinates were received, the action 338 includes the collection and formatting of the measurement data (or geo-coordinates), and the responsive position indication signal 342 carries the formatted information to the mobile switching center 302. In a manner similar to that illustrated in FIGURE 11, the responsive position indication signal 342 is sent in accordance with the method of reporting parameter contained within the position/tracking request signal 350. Following receipt of the forwarded tracking response signal 360 in the form of the responsive position indication signal 342, the mobile switching center 302 sends a confirmation signal 362 to the base station system 308.

The network 300 then proceeds to authenticate (action 364) the mobile station 312 in a manner well known to those skilled in the art. If the authentication is successful, the mobile switching center 302 is then authorized (action 366) to report position information to the monitoring center 320 (as shown) of the requesting law enforcement agency using the request location information response signal 346. If position information was received in (or obtained from) the forwarded tracking response signal 360, this information is then reported following authorization to the requesting entity in accordance with the method of reporting parameter contained within the position/tracking request signal 350. If no position information was yet received, or if additional information is expected, completion of the authentication process 364 authorizes subsequent base station system 308 transmission of the responsive position indication signal 342 in accordance with the method of reporting parameter contained within the position/tracking request signal 350.

Again, the location processing device 340 need not be directly connected to the base station system 308. Instead, or additionally, the device 340' may be directly connected to the mobile switching center 302. In such a case where the position determination is not made in association with the base station system 308 (i.e., the action 338 involves the collection of the and formatting of the measurement data), the measurement data is transmitted to the mobile switching center 302 in the position indication signal 342 and the requested position request determination (action 338') is thereafter made by the location processing device 340'.

Reference is now made to FIGURE 13 wherein there is shown a block diagram of a cellular telephone network 400 equipped to provide emergency situation caller assistance. The cellular telephone network 400 includes a plurality of mobile switching centers (MSC) 402. Associated with each mobile switching center 402 is a base station controller (BSC) 404 connected to a plurality of base stations (BS) 406. Each base station controller 404 and its associated base stations 406 form a base station system (BSS) 408. Each base station 406 is configured to engage in radio frequency communications over an air interface 410 with proximately located mobile stations (MS) 412. The air interface 410 supports the transmission of both voice/data communications as well as signaling communications. In general, communications are effectuated with those mobile stations 412 located near or within the confines of a cell 414 associated with each base station 406. The mobile switching center 402 and base station controller 404 are connected via a communications link 416 which supports the transmission of both voice/data communications as well as signaling communications. The base station controller 404 and associated base stations 406 are connected via communications links 418 which, like the links 416, support the transmission of both voice/data communications

as well as signaling communications. The mobile switching centers 402 are interconnected by communications links 420 which, like the links 416 and 418, also support the transmission of both voice/data communications as well as signaling communications. Operation of the cellular telephone network 400 in providing conventional cellular voice/data calling services to mobile station subscribers is well known to those skilled in the art, and accordingly will not be discussed herein.

Connected to the cellular telephone network 400 via routers 423 are a plurality of public safety answering point (PSAP) systems 422. Each public safety answering point system 422 is utilized by emergency service providers (such as the police department, fire department, or rescue department) as a central point for the reception of emergency services telephone calls (e.g., dial 911 calls) and the dispatching of emergency services personnel within an associated emergency service area. Certain mobile switching centers 402 are assigned to a certain public safety answering point system 422. In fact, it is possible that one mobile switching center 402 may be serviced by more than one public safety answering point system 422.

It is important that any cellular emergency call initiated from a mobile station 412 be handled by the proper public safety answering point system 422. Generally, this means the public safety answering point system 422 controlling the dispatching of proximately located emergency services personnel. If a cellular emergency call is misrouted, the dispatching and/or arrival of emergency aid could be delayed. Under normal cellular telephone system operating conditions, this is not a concern as the cellular emergency call is handled by the mobile switching center 402 for the service area where the emergency call is originated (the serving MSC) and routed through router 423 to the public safety answering point system 422 connected thereto. For those

situations where a service area and its mobile switching center 402 are associated with plural public safety answering point systems 422, routing is made to the public safety answering point system 422 assigned to the cell 414 currently serving the mobile station 412. When the mobile subscriber is on-call, roaming and switches serving mobile switching centers 402, however, a communications link is maintained through the mobile switching center 402(1) for the service area where the first call was originated (the anchor MSC). Any cellular emergency call thereafter initiated (by placing the original call on hold) is then incorrectly, and perhaps undesirably, routed through the anchor mobile switching center 402(1) to its assigned (connected) public safety answering point system 422 via router 423 instead of to the public safety answering point system 422 for the serving mobile switching center 402(2).

Reference is now additionally made to FIGURE 14 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 400 of FIGURE 13 in providing location information on a mobile station 412 for purposes of routing an emergency cellular call to the proper public safety answering point system 422. In conjunction with anchor mobile switching center 402(1) receipt of a cellular emergency call 424 originated by a roaming mobile station 412 while maintaining an original call 425 (on hold), an identification is also provided of the cell 414 associated with base station 406 serving the mobile station. The data base 426(1) connected to the anchor mobile switching center 402(1) does not include translation information correlating the identified cell 414 with the routing identification number for its associated public safety answering point system 422. This is because this information is instead stored in the data base 426(2) connected to the serving mobile switching center 402(2). Thus, the anchor mobile switching center

402(1) does not possess sufficient information to properly route the call.

Recognizing then the situation of a roaming mobile station 412 making a cellular emergency call 424 with a prior call 425 on hold, the anchor mobile switching center 402(1) sends a position request with location number requested signal 428 to the serving mobile switching center 402(1) over the communications link 420 as a Mobile Application Part (MAP) message. This position request signal 428 optionally includes an identification of the cell 414 where the mobile station 412 is located, and a location type parameter which requests the return of a routing identification number for that cell. Responsive to receipt of the location number request signal 428, the serving mobile switching center 402(2) processes (action 430) the identified cell in its data base 426(2) which includes translation information correlating the identified cell 414 with the routing identification number for its associated public safety answering point system 422. The retrieved routing identification number is then included in a response signal 432 transmitted from the serving mobile switching center 402(2) to the anchor mobile switching center 402(1) over the communications link 420. Using the retrieved routing identification number, the anchor mobile switching center 402(1) forwards (action 434) the cellular emergency call 424 to the public safety answering point system 422 assigned to the cell 414 currently serving the mobile station 412.

Instances may arise where position information regarding the roaming, cellular emergency calling mobile station 412 is also needed to handle the call. One option is for the transmitted signal 428 to be treated by the network 400 as a position request signal 332 (see, FIGURE 11) as well. Responsive thereto, and via the maintained connection through the anchor mobile switching center 402(1), the serving mobile switching center 402(2) not only retrieves the routing identification number for the

proper public safety answering point system 422 for delivery to the anchor mobile switching center, but also initiates the position determination procedure illustrated in FIGURE 11. Following receipt of each position indication signal 342 by the anchor mobile switching center 402(1), the position information is processed and/or formatted (action 344), if necessary, and a request position information response signal 346 is transmitted from the mobile switching center to the proper public safety answering point system 422 via the anchor mobile switching center 402(1). Alternatively, in response to the forwarding (action 434) of the cellular emergency call 424, the public safety answering point system 422 transmits a position request signal 332 (see, FIGURE 11) towards the serving mobile switching center 402(2) via the anchor mobile switching center 402(1). Following receipt of each position indication signal 342 by the serving mobile switching center 402(2), the position information is processed and/or formatted (action 344), if necessary, and a request position information response signal 346 is transmitted to the public safety answering point system 422 via the anchor mobile switching center 402(1).

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. In a cellular telephone network including a first mobile switching center currently serving a target mobile station and a second mobile switching center currently serving a requesting mobile station, a method comprising the steps of:

routing a request for target mobile station position made by the requesting mobile station from the second mobile switching center to the first mobile switching center;

processing position indicative information to determine a position of the target mobile station; and

routing a response to the position request including target mobile station position from the first mobile switching center to the second mobile switching center.

2. The method as in claim 1 wherein the cellular telephone network includes a first public land mobile network having the first mobile switching center and a second public land mobile network having the second mobile switching center, and the steps of routing comprise the steps of routing the position request and response between the first and second public land mobile networks.

3. The method as in claim 2 wherein the first public land mobile network includes a home location register for the target mobile station, and the steps of routing further comprise the steps of routing the position request and response between the first and second mobile switching center through the home location register.

4. The method as in claim 1 wherein the cellular telephone network includes a public land mobile network having both the first and second mobile switching centers.

5. The method as in claim 1 further including the step of verifying requesting mobile station subscription

to a service feature supporting the request for target mobile station position.

6. The method as in claim 1 further including the steps of:

forwarding the response to the position request including target mobile station position from the second mobile switching center to the requesting mobile station;

processing of the included target mobile station position; and

displaying at the requesting mobile station of the target mobile station position.

7. In a telephone network including a public switched telephone network connected through an end office exchange to a requesting subscriber station and a cellular telephone network having a mobile switching center currently serving a target mobile station, a method comprising the steps of:

routing a request for target mobile station position made by the requesting subscriber station from the end office exchange to the mobile switching center;

processing position indicative information to determine a position of the target mobile station; and

routing a response to the position request including target mobile station position from the mobile switching center to the end office exchange.

8. The method as in claim 7 further including the step of verifying requesting subscriber station subscription to a service feature supporting the request for target mobile station position.

9. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to the requesting subscriber station; and

delivering the target mobile station position to a requesting subscriber as a synthesized voice message.

10. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to a facsimile machine associated with a requesting subscriber; and

delivering the target mobile station position to the requesting subscriber as a facsimile message.

11. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to a data terminal associated with a requesting subscriber; and

delivering the target mobile station position to the requesting subscriber as a data message.

12. The method as in claim 7 wherein the mobile switching center is connected to a home location register of the target mobile station, and the steps of routing comprise the steps of routing the position request and response between the mobile switching center and end office exchange through the home location register.

13. In a cellular telephone network including mobile switching center connected to a base station system currently serving a target mobile station, a method comprising the steps of:

receiving at the mobile switching center a request from a requesting entity for target mobile station position;

routing the request for target mobile station position to the base station system currently serving the target mobile station;

collecting by the base station system of target mobile station position indicative information;

processing the position indicative information to determine a position of the target mobile station; and

routing a response including the target mobile station position through the mobile switching center to the requesting entity.

14. The method as in claim 13 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the target mobile station itself.

15. The method as in claim 14 wherein the position related measurement information comprises signal strength measurements.

16. The method as in claim 14 wherein the position related measurement information comprises timing advance measurements.

17. The method as in claim 13 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the base station system itself.

18. The method as in claim 17 wherein the position related measurement information comprises signal strength measurements.

19. The method as in claim 17 wherein the position related measurement information comprises timing advance measurements.

20. The method as in claim 13 wherein the step of collecting comprises the step of obtaining geo-coordinate information collected by the target mobile station itself.

21. The method as in claim 13 wherein the position indicative information comprises position related measurement information, and the step of processing

comprises the step of arcuating the position related measurement information to determine the target mobile station position.

22. The method as in claim 13 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of triangulating the position related measurement information to determine the target mobile station position.

23. The method as in claim 13 wherein the target mobile station is operating in an on-call mode, and wherein the step of routing comprises the step of routing the request to the base station system through which the target mobile station call is being handled.

24. The method as in claim 13 wherein the target mobile station is operating in an idle mode, and wherein the step of routing comprises the steps of:

paging for the target mobile station; and

routing the request to the base station system through which the target mobile station answers the page.

25. The method as in claim 13 further including the step of authenticating the target mobile station before allowing any target mobile station position response to be sent to the requesting entity.

26. A method, comprising the steps of:

responsive to mobile station hand-off during a first call from a first mobile switching center to a second mobile switching center, and further responsive to mobile station initiation of a second, emergency call while maintaining the first call, transmitting a request for mobile station location from the first mobile switching center to the second mobile switching center;

processing a current cell location for the mobile station to identify a public safety answering point serving the mobile station;

transmitting a response including the identified public safety answering point from the second mobile switching center to the first mobile switching center; and

routing the second, emergency call to the identified public safety answering point.

27. The method as in claim 26 further including the steps of:

collecting position indicative information for the mobile station;

processing the position indicative information to determine a position for the mobile station; and

routing the determined mobile station position to the identified public safety answering point.

28. The method as in claim 27 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the target mobile station itself.

29. The method as in claim 28 wherein the position related measurement information comprises signal strength measurements.

30. The method as in claim 28 wherein the position related measurement information comprises timing advance measurements.

31. The method as in claim 27 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the base station system itself.

32. The method as in claim 31 wherein the position related measurement information comprises signal strength measurements.

33. The method as in claim 31 wherein the position related measurement information comprises timing advance measurements.

34. The method as in claim 27 wherein the step of collecting comprises the step of obtaining geo-coordinate information collected by the target mobile station itself.

35. The method as in claim 27 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of arcuating the position related measurement information to determine the target mobile station position.

36. The method as in claim 27 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of triangulating the position related measurement information to determine the target mobile station position.

FIG.1

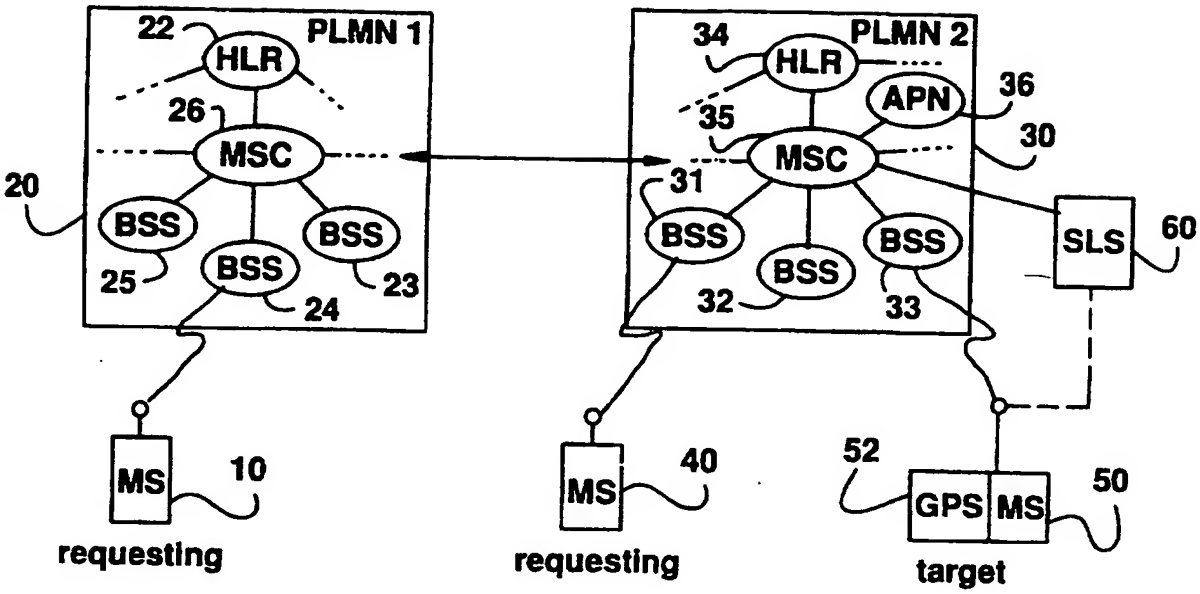


FIG.2

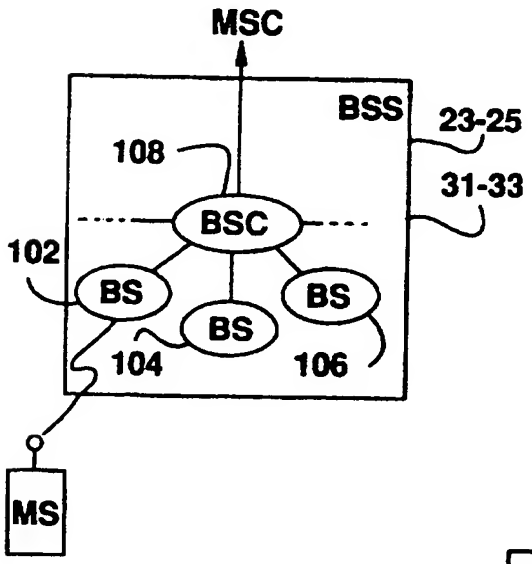


FIG.5

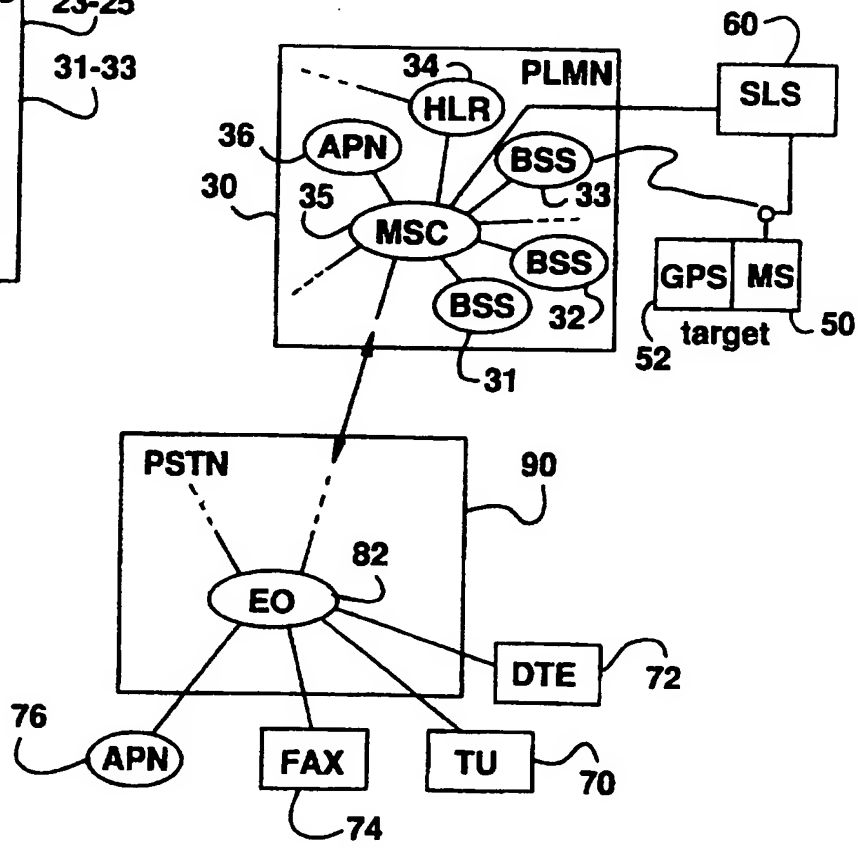
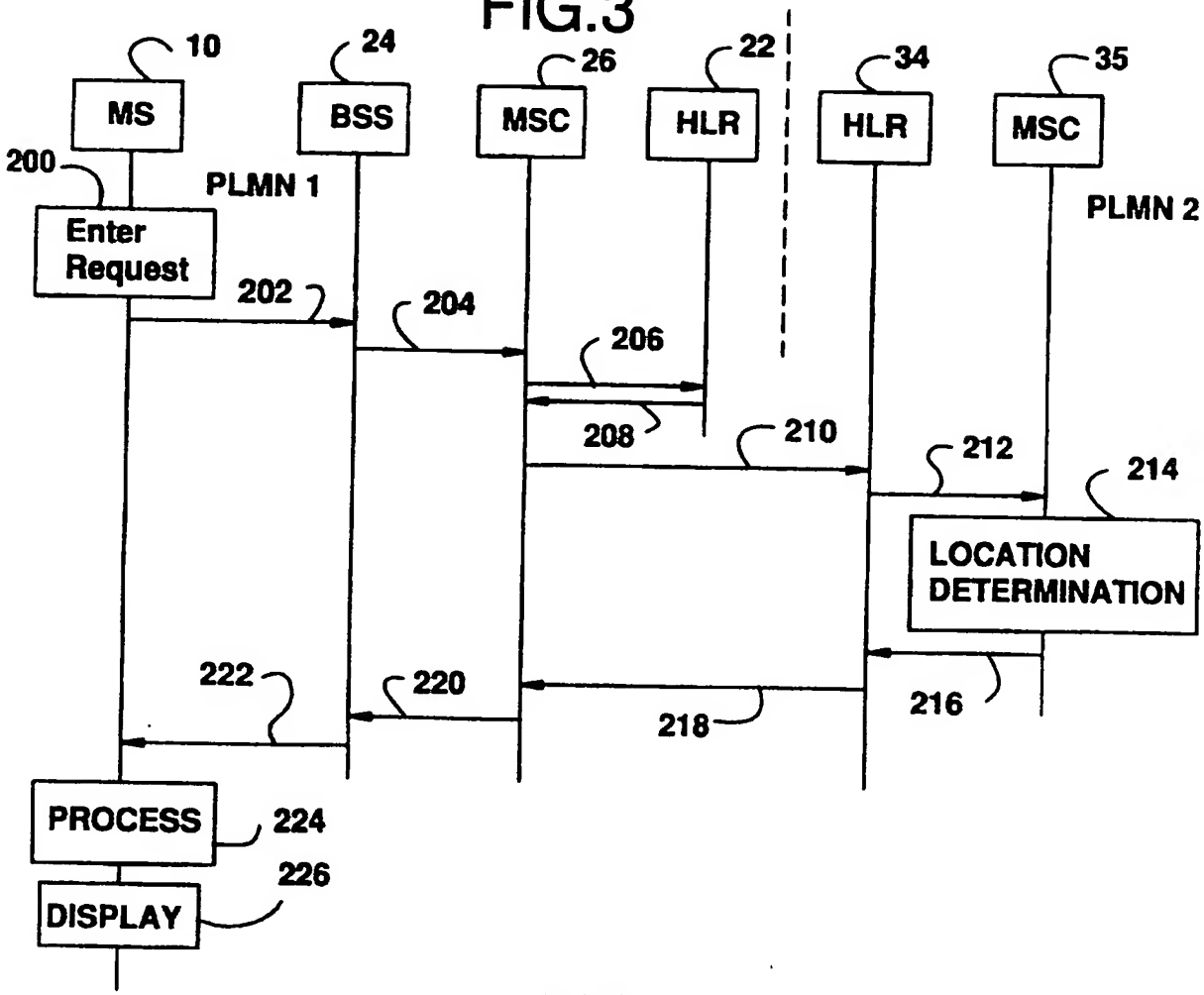


FIG.3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MS
24
BSS
26
MSC
22
HLR
34
HLR
35
MSC
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PLMN 2
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214
LOCATION DETERMINATION
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218
216
PROCESS
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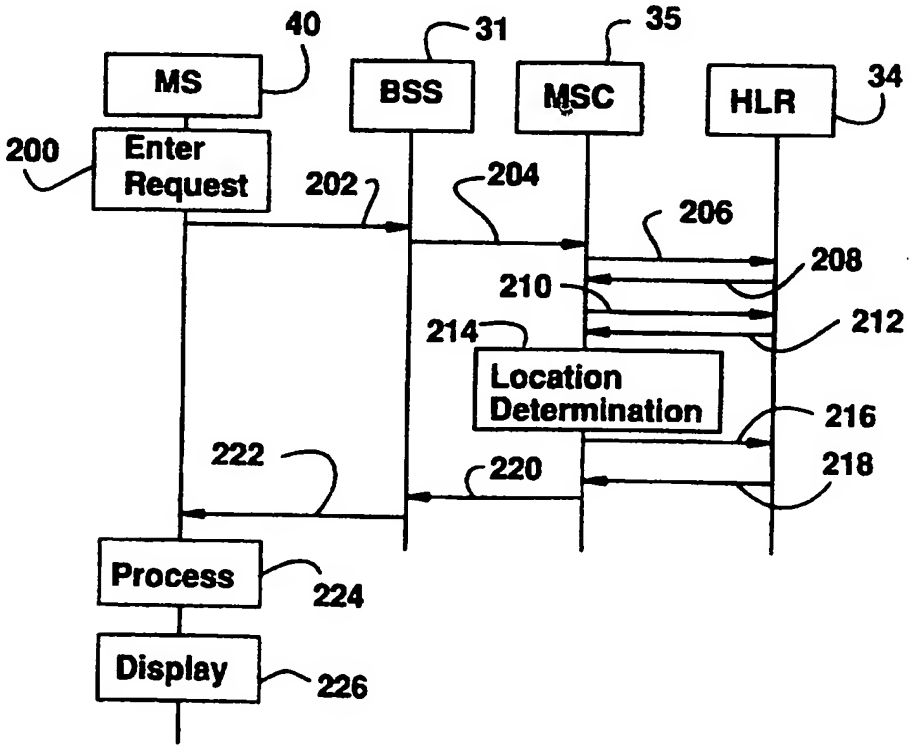
DISPLAY

FIG.4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MSC
HLR
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Location Determination
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Process
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Display
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FIG.6

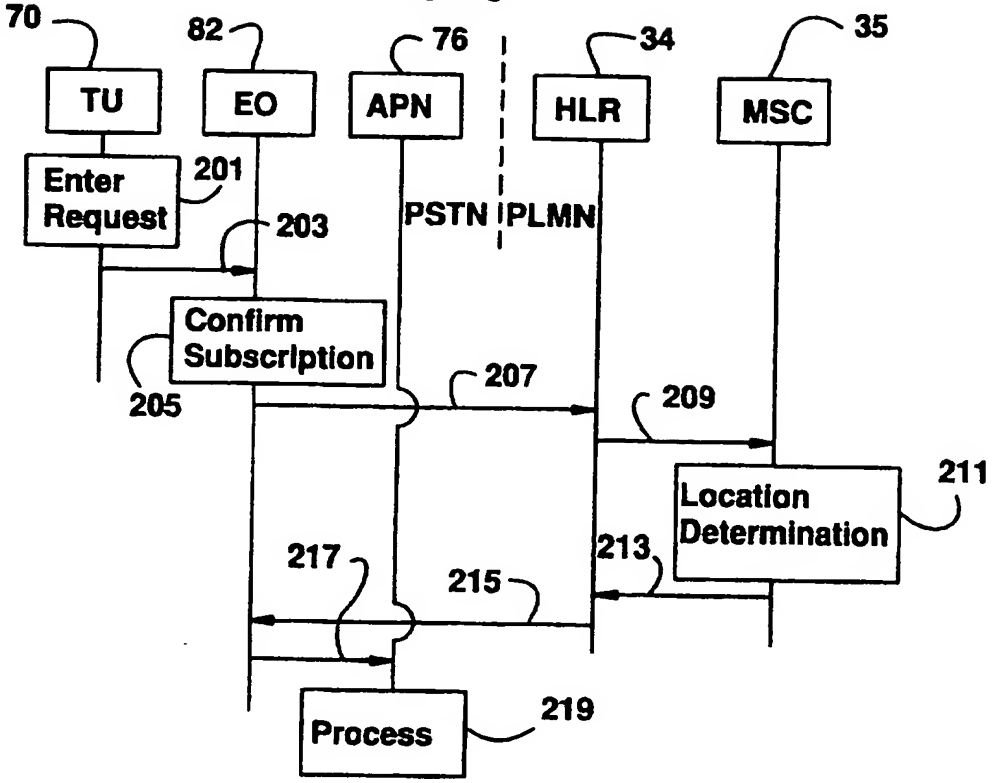


FIG.7

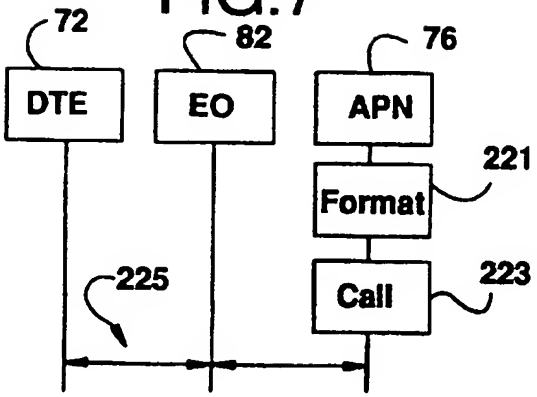


FIG.8

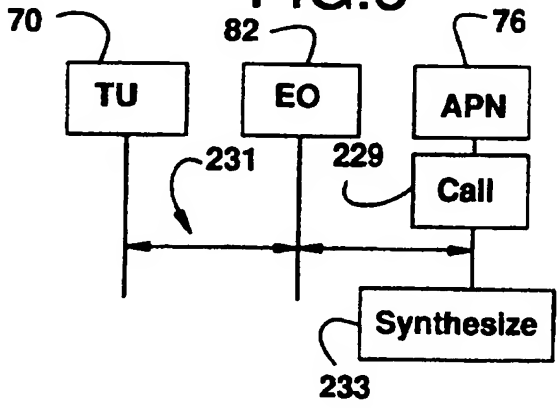


FIG.9

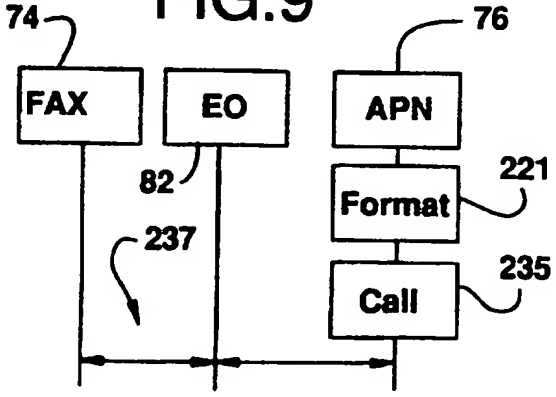
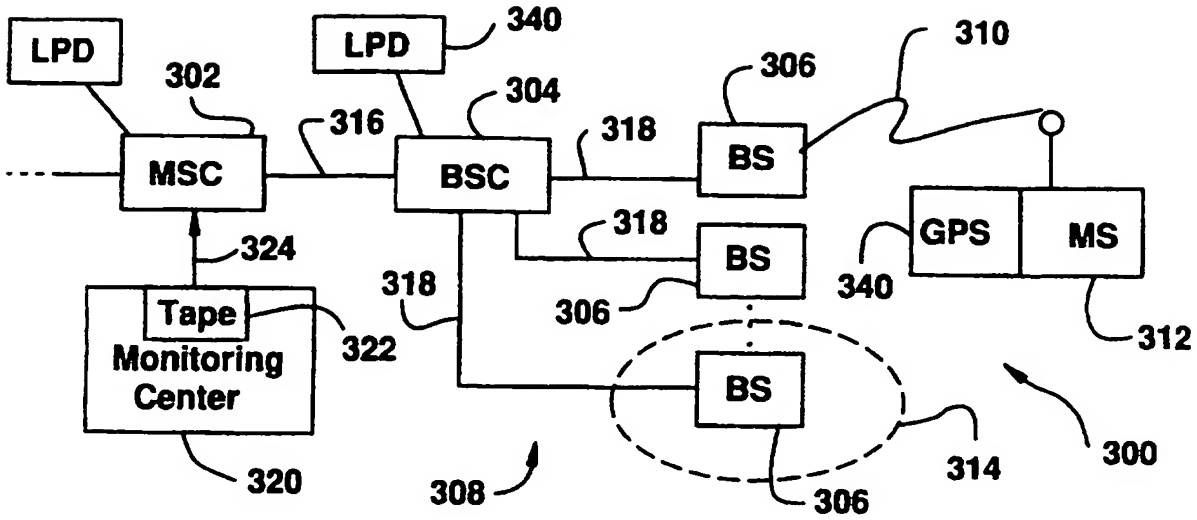


FIG.10


LPD
LPD
340
302
304
306
310
316
318
MSC
BSC
BS
GPS
MS
318
324
BS
340
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Tape
Monitoring
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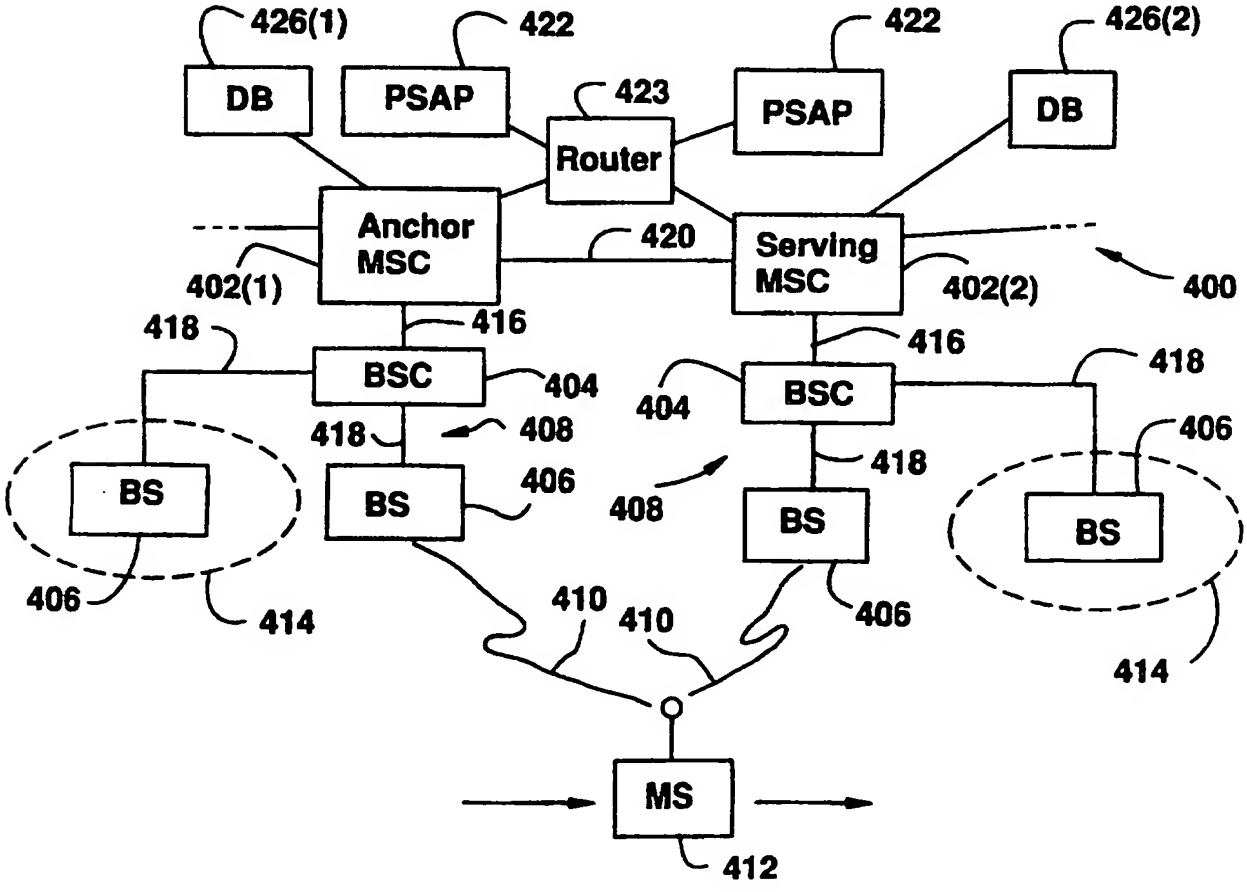
312
BS
314
300
320
308
306

FIG.13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422
426(2)
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PSAP
423
PSAP
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Router
Anchor
MSC
420
Serving
MSC
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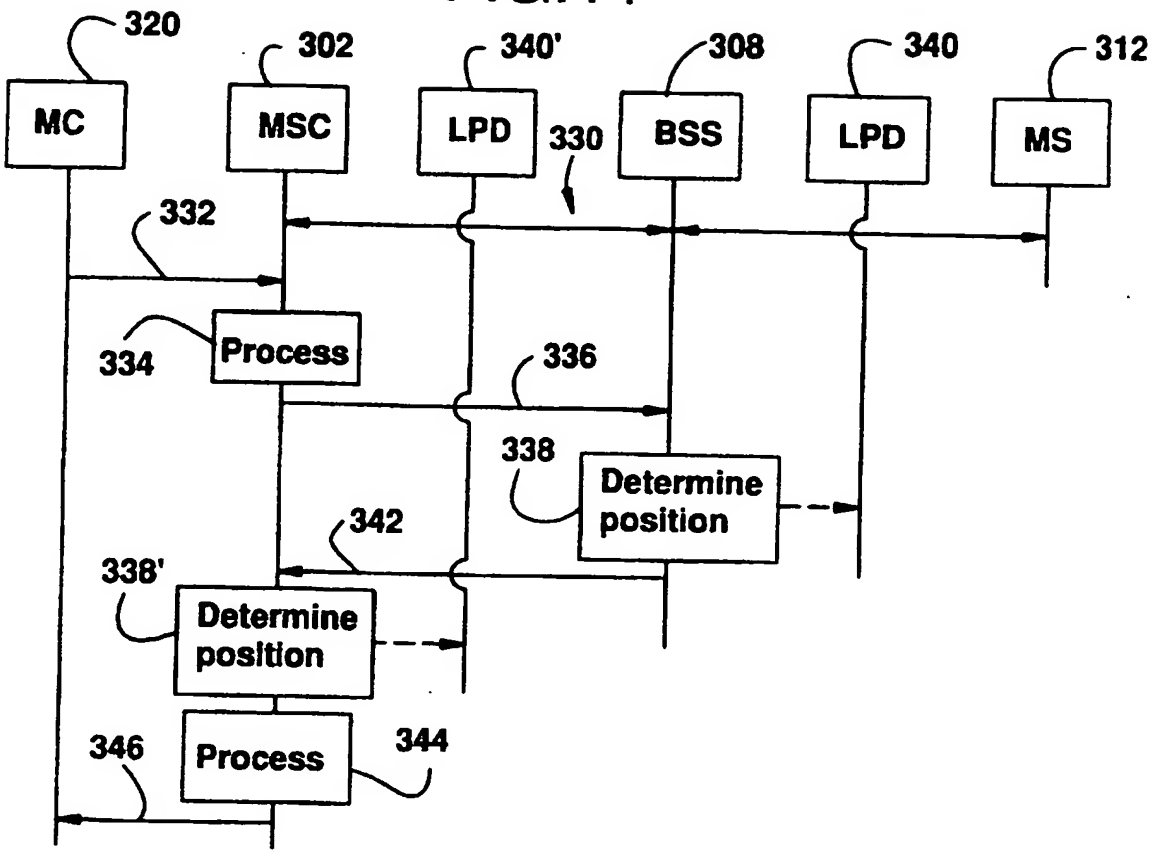
414
414
MS
412

FIG.11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MC
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MSC
340'
LPD
308
BSS
330
340
LPD
312
MS
332
334
Process
336
338
Determine position
342
338'
Determine position
346
Process
344

FIG.12

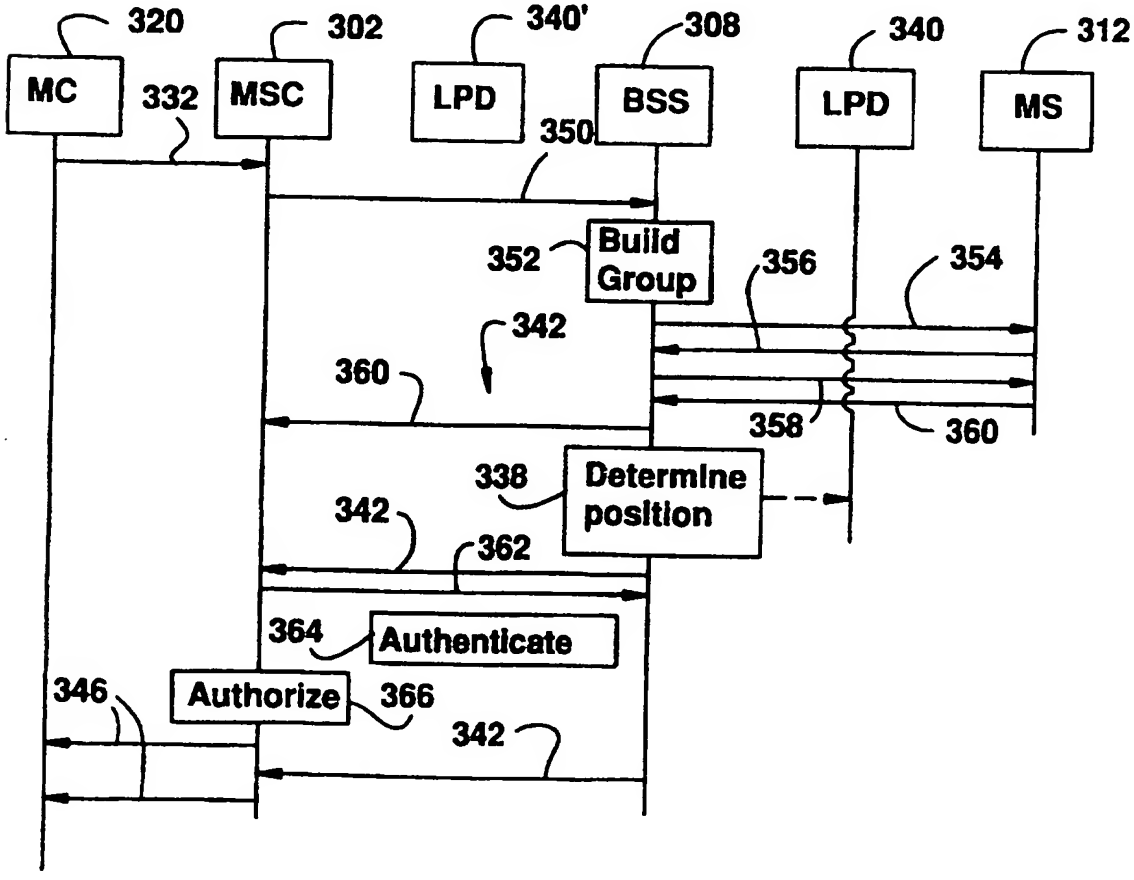
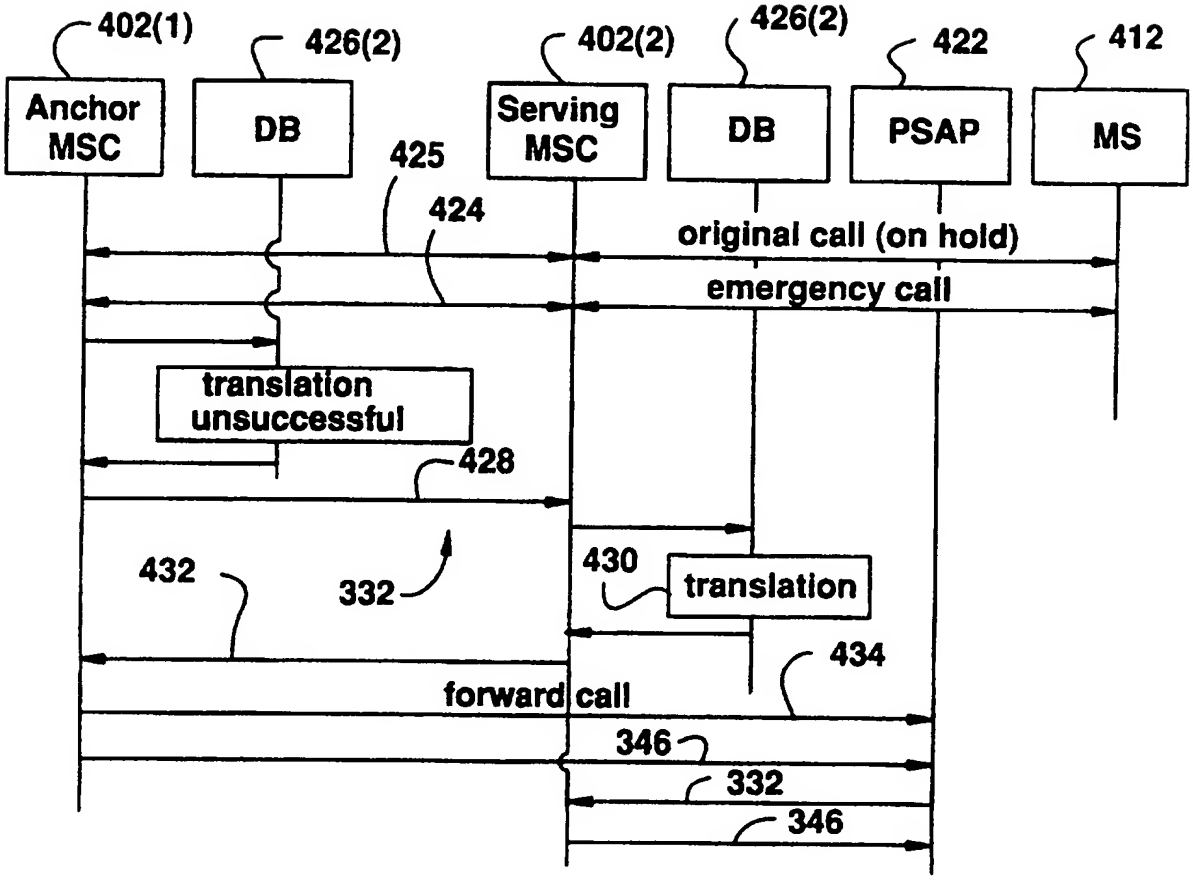

320
MC
302
MSC
340'
LPD
308
BSS
340
LPD
312
MS
332
350
352
Build Group
356
354
342
360
358
360
338
Determine position
342
362
364
Authenticate
346
Authorize
366
342

FIG.14


402(1)
426(2)
402(2)
426(2)
422
412
Anchor MSC
DB
Serving MSC
DB
PSAP
MS
425
424
original call (on hold)
emergency call
translation unsuccessful
428
432
332
430
translation
434
forward call
346
332
346